

Author: Marko Ala-Fossi

Terrestrial broadcasting in Europe after WRC-15: an End of an Era or a New Beginning?

The World Radiocommunication Conference of the International Telecommunication Union (ITU) in November 2015 (WRC-15) was not even completely over yet when another international organization also headquartered in Geneva, Switzerland – the European Broadcasting Union (EBU) published a press release with a title “Broadcasters applaud WRC-15 decision securing future of free-to-air broadcasting” (EBU 2015a). The European broadcaster’s worst nightmare – losing the priority of TV broadcasting for exclusive use of the remaining part of UHF band below 700 MHz in the ITU Region 1 had been successfully defeated with the support of altogether 150 governments. And moreover, it was also agreed that the status of the UHF would not be touched or even reviewed until eight years later at the WRC-23. So this result could easily be regarded as a complete success for European broadcasting. Unfortunately, the consequences of the WRC-15 are far more complex. This chapter examines them from three different perspectives.

Slightly adapting the lines which the former British Prime Minister Winston Churchill used to praise the Royal Air Force pilots in 1940¹, the result of the WRC-15 could be described by saying that *never in the field of broadcasting was so little celebrated so much by so many*. The European broadcasters were cheerfully applauding for simply maintaining what was left of the earlier status quo, but at the same time WRC-15 confirmed that digital terrestrial television will lose about 30 percent of its spectrum resources (96 MHz) and digital radio broadcasting over 40 percent of its spectrum allocations (40 MHz) in Europe. The European broadcasters have probably never lost such a large amount of spectrum to be reallocated for other purposes in a single WRC. But it was perhaps a small sacrifice when compared to possibility of losing the entire UHF band – and there was not much left to be done to change the outcome. The battle for 700 MHz was in practice lost already at WRC-12 and by leaving the L-band unused, the broadcasters themselves had sealed

¹ “Never in the field of human conflict was so much owed by so many to so few.” See <http://www.winstonchurchill.org/resources/speeches/1940-finest-hour/113-the-few>

its destiny. The loss of spectrum will have a direct, widespread and profound impact on the future of European television and indirectly also on the development of radio broadcasting.

In addition, if the European broadcasters really thought that the outcome of the WRC-15 would bring the UHF spectrum band “peace for our time”², like Neville Chamberlain - another former British Prime Minister - put it after the notorious Munich Conference in September 1938, it soon turned out that the future of the UHF band in Europe was going to be much less safe and secure than expected. In February 2016, the European Commission started to prepare the Europe-wide clearance of the 700 MHz band from television use and its coordinated reallocation for mobile broadband internet use in. As a part of this plan the Commission introduced also “flexibility option” so that the member states could start using part of the dedicated UHF broadcast spectrum below 700 MHz for other purposes, primarily downlink wireless broadband (EC 2016a; 2016b). The EBU immediately expressed its serious concern (EBU 2016), but it is hardly surprising that the Commission is trying to promote its ambitious economic goals for the Digital Single Market with all possible means while protecting (at least the most of) the remaining UHF. In addition, the idea of flexible downlink-only use of the 470-694 MHz band was not completely new, but discussed as an option already in the consultation round of the Lamy Report in 2015 (EBU 2015b)

Interestingly enough, the European Commission had proposed the EU member states to make a binding joint decision of the European Council on voting about the future of UHF at WRC-15 in advance. The member states formally rejected this idea, as spectrum policy belongs strictly in the national competence, but the European governments were practically unanimous in their support at WRC-15 for saving the lower part of UHF band for terrestrial television broadcasting. All, except one. Quoting the exact words of Winston Churchill, Finland showed again “what free men can do”³ and voted against all the other European Union member states to support the release of entire UHF

² See <http://www.britannia.com/history/docs/peacetime.html>

³ See <http://www.winstonchurchill.org/resources/speeches/233-1940-the-finest-hour/98-the-war-situation-house-of-many-mansions>

band for mobile use on a co-primary basis. This time, the fight against a superior opponent was perhaps highly glorious at least to some, but if possible, even more unsuccessful than 75 years earlier (against the Soviet Union). (GSMA 2015; Pursiainen 2015) This episode illustrates how there are multiple political and economic reasons why even the governments of the EU member states are no longer able to agree on the importance of broadcasting for maintaining and renewing the European democracy and culture.

Spectrum release as a by-product of digital TV vs. forced switchover to release spectrum

Releasing the (first) digital dividend was in many ways more gentle process for the European broadcasters than the clearing of the 700 MHz band, which is now about to begin. Although digitalization of television was an expensive and burdensome process, many European countries and broadcasters were very eager to go digital and to invest in to their future (!), to expand their opportunities to create new services and set up new channels. Many governments eventually put their well-resourced national public service broadcasters in charge to drive the process of digitalization as locomotives and even used their assets to cover the expenses. The main focus of the broadcasters was naturally somewhere else than in clearing the spectrum – while the huge potential economic value of “reinvesting the analogue spectrum” (Galperin 2004, 166) had been well understood by the governments already in the mid-1990s, before any national decisions about digitalization were made (Ala-Fossi and Bonet 2016).

There was relatively lot of time for making the changes. For example in Finland, it took over 11 years from the Council of State decision in May 1996 to actually switching off the last analogue TV transmitter at the end of August 2007, six years after the introduction of digital TV service. An international agreement about the location of the digital dividend in the upper UHF band and its future purpose was reached couple of months later at WRC-07, and after that the EU member states officially had five more years for clearing the 800 MHz band for mobile by the end of 2012. Only

11 states actually met that goal. Even an early bird to complete the transition like Finland was not able to introduce 4G services on 800 MHz until in January 2014. So the process as a whole took altogether about 18 years.

This time, the process of releasing more UHF spectrum in Europe is most of all driven by the mobile industry (Ala-Fossi and Lax 2016; Harvey and Ala-Fossi 2016). We can perhaps assume that any of the European broadcasters had not even seriously considered the possibility of losing the 700 MHz band before the WRC-12, so they probably had not made any plans for abandoning it in advance. Now as the reallocation of the band was confirmed at WRC-15, the European Commission suggested that the process of clearing the 700 MHz band as the second digital dividend should be completed in 4.5 years, by the end of June 2020 in all EU countries (EC 2016). This leaves less than 8 years between the very first surprise and actually getting out of the way of the new mobile broadband services. So the timetable of this second transition is a bit ambitious - especially because some member states have nationally licenced the 700 MHz band for broadcast use beyond 2020 (EP 2016, 3).

The second digital dividend (96 MHz) is not only about 30 per cent of the current spectrum resources of television in Europe, but also more than 30 per cent larger piece of the UHF spectrum than the first one (72 MHz). In addition, the number of the digital terrestrial television (DTT) channels to be moved is now significantly higher than it was at end of the analogue age. According to a recent consultancy report commissioned by the EU, a simple re-stacking of the existing services into the remaining parts of the UHF would not be enough. For example, in Finland 21 and in Spain 44 transmitters would be left without a UHF frequency to operate on (LST 2016, 28). This means that the only rational way to clear more UHF spectrum in Europe without closing down a large number of existing DTT services is a transition to a more advanced and spectrum-efficient version of the digital television technology standard. In other words, a second and this time also all-digital switchover from an old digital TV system (DVB-T) to a new digital TV system (DVB-T2). The

challenges are almost the same as with the earlier switchover, although this time even some broadcasters expect that even the new digital broadcast television system will not be used very long beyond 2030 but replaced by internet protocol (IP) delivery over telecom networks (Ala-Fossi and Lax 2016). The future for the additional technology investments which the broadcasters and the consumers are now forced to make is much less stable and clear than before. Thanks to the “flexibility option” there would be no guarantee about any length of the lifecycle of DVB-T2 or about sufficient resources for DTT. Moreover, all that money could have well been used for many other purposes.

The cost of necessary re-engineering of the DTT networks in the EU countries has been estimated to be €888 million at the most – while the potential user equipment expenses range from €492 million to €169 million a) depending on the version of the replacement system (DVB-T2/ MPEG4 or DVB-T2/ HEVC) and b) the speed of the transition – or the length of the period of simulcasting services with both old and new systems (LS telecom 2016, 80). Finland was the first in Europe (2012) to make a national decision about clearing the 700 MHz band and it was planning to continue simulcasting until 2026, but in April 2016 the Finnish broadcasters agreed on completing the transition already 2020. The first generation digital TV (DVB-T) in Finland will then reach only the age of 19 (2001-2020). A shorter simulcasting period saves broadcaster’s distribution expenses but forces more consumers to replace their reception equipment prematurely. For example, France is accelerating the clearance of 700 MHz band with state aid of €56.9 million for supporting the households with most extra expenses caused by the transition (EC 2016c). It is perhaps interesting that the mobile industry is not supposed to take part in any of these additional costs, although this whole expensive process is about clearing more spectrum space for expanding its commercial business.

It is not a secret of any kind that the mobile industry would like to overtake the entire UHF band everywhere for mobile broadband use to create a global market for compatible mobile systems

and devices. Several countries including the United States, Canada and Finland supported already at the WRC-15 the idea of releasing the UHF from exclusive broadcast use for both broadcast and mobile use. So far, this kind of change has eventually led into complete reallocation of the particular spectrum into mobile use only. No wonder that the LS telecom report (2016) for the Commission has included also this scenario. The pressure on UHF is there already and it is not likely to decrease in the coming years, especially because the US and Canada have already decided to repurpose the 600 MHz band from broadcasting to mobile and the Commission plans “flexible use” of sub-700 MHz. In practice, opening the lower part of the UHF for mobile broadband downlink use on the basis of national decisions would be very much in line what Finland was already suggesting at WRC-15. No wonder that this time the Finnish government would be absolutely happy to follow the European Commission proposal to the letter (MINTC 2016) while the European Parliament Committee on Culture and Education of the is strictly against it (EP 2016). In this context, it is very likely that the space available on UHF band may shrink further for a reason or another even if Europe could stick to TV broadcasting on that particular part of spectrum.

This in turn will challenge the long-time European efforts to switch from analogue to digital terrestrial radio, which have so far taken up more spectrum space for audio broadcasting instead of creating any digital dividend. Ironically, the only spectrum release provided by digitalization of radio was so called L-band (1452-1479.5 MHz), which was reallocated for mobile use at WRC-15 because nobody had eventually taken it for digital radio use. Digital Audio Broadcasting (DAB) was originally developed to replace analogue FM on the VHF II band, more commonly known as the FM band (87.5-108 MHz). However, the broadcasters rejected the idea of switching off FM radio in the 1990s. So DAB was then instead introduced on VHF III (174-230 MHz), spectrum recently released from analogue television. So far, only Norway has made official plans for switching off nationwide FM. There are several European countries where DAB/DAB+ radio occupies the entire VHF III spectrum (56 MHz), but where FM radio with significantly less

spectrum on VHF II (20,5 MHz) still has more listeners - and in this way, perhaps more spectrum efficient. Although the success of DAB among listeners has not been as good as originally expected, it may have turned into a strategic blocking tool in the battle over the European UHF spectrum. As long as it exists, the broadcasters can use it as an excuse for not releasing more UHF for mobile by using the VHF III band for television. In Finland VHF III was reallocated for DVB-T2 television use in 2009, four years after switching off DAB radio. (Ala-Fossi 2016c; Ala-Fossi and Bonet 2016)

The EU Commission is economically rational rather than simply logical

When the current President of the European Commission, Jean-Claude Juncker started his five-year term in 2014, he made a Europe-wide reform of spectrum management one of his first priorities. According to Juncker, “breaking down the national silos” in the management of radio waves was essential for creating a digital single market providing growth and jobs in Europe (Juncker 2014). The idea of EU-wide spectrum management agency was suggested for the first time already in 2006 by Viviane Reding, who was at the time a European Commissioner for the Information Society. Reding thought that it was a competitive disadvantage for Europe to have a number of nation-based spectrum management agencies instead of just one centralized agency for the entire market like in the US, but her proposal for establishing European Electronic Communications Market Authority (EECMA) was determinedly rejected by the member states. Seven years later in 2013, Redings successor, the European Commissioner for the Digital Agenda Nellie Kroes tried to include a major spectrum management reform into the new EU Telecom Package, but by the time the legislation was adopted in 2015, there were no traces of any spectrum measures (Sims et al. 2015, 190-193). So there is a tension between the EU member states and the European Commission, who wants to centralize the management of radio spectrum for the common good through the harmonization of spectrum use.

The efforts of the Commission to increase its power on European spectrum management are most probably not reflecting any strict federalist strategy as much as its tendency to see the radio spectrum primarily as an economic resource, which management and commercial use should be harmonized on the European level for maximum economic output. There is no doubt whether the Commission is aware of the economic importance of the spectrum as vital resource for future growth. The spectrum has been described as “the lifeblood of Information Society” by Viviane Reding (EC 2005) and later on, increasingly less dramatic way as “economic oxygen” by Nellie Kroes (EC 2012) and most recently as “oxygen for the internet” by Andrus Ansip (EC 2015). But the Commission does not seem to understand very well the importance of the radio spectrum for other than economic purposes in fields outside of its own jurisdiction. Especially in the NATO member states (22 of the 28 EU member states), the military is one the most important users of the spectrum. For example in the UK, a bit over half of the radio spectrum is occupied by the public sector, and 75 per cent of this space below 5GHz is used by the British Ministry of Defence, which usually does not even specify the exact purposes for national security reasons. (Sims et al. 2015, 56, 179) So it is very hard to imagine that the member states would ever let the EU to take over the management of the entire radio spectrum in Europe.

In general, it could be argued that in its pursuit to promote economic growth, the European Commission is primarily economically rational, pragmatic and even opportunist rather than purely logical. Although the European Union officially follows the principle of technological neutrality- not taking a stand for or favouring any system over another but letting the market forces to decide (Kamecke and Körber 2008) - the Commission has not been even a bit embarrassed or apologetic in its attempts to totally bypass the market mechanisms to promote and favour a European technology over other options when possible. For example, the EU Commission made its support for DVB-H digital mobile TV system developed by Nokia in Finland very clear. It even made DVB-H one of the Official standards of the EU, hoping that it would help this system conquer the entire world.

Although DVB-H system was considered to be a brilliant piece of engineering, but it turned out to be a commercial failure in the consumer markets. (Sims et al. 2015, 192; Ala-Fossi 2016a, 279)

This makes it perhaps easier to understand why the European Commission has on the one hand been striving very hard to create Europe-wide decisions over protecting the UHF spectrum for broadcast use, but on the other hand it has also introduced a “flexibility option” for an alternative use of the broadcast spectrum - which is in fact increasing the risk of national fragmentation of the UHF spectrum use as well as introducing a risk of additional interference for broadcasting (LST 2016; EP 2016). European harmonization of the national schedules for the 700 MHz spectrum release is likely to promote new economic activity, but saving the remaining UHF band exclusively for broadcasting is not. Instead, the Commission would like to see at least some EU member states to introduce also LTE-based broadcast / downlink services, based on another European technology originally developed by Ericsson to compete with DVB-H (Multimedia Broadcast Multicast Service, MBMS). To summarize, from the perspective of the European Commission, the radio spectrum is most of all a key economic resource for the future growth – which is most likely created with something else than traditional broadcasting.

Although the European broadcasters should not rely on the European Union and the European Commission simply as friends or loyal supporters, which would always provide supranational protection for the broadcast spectrum, they should see EU as a useful strategic ally. The EU is supposed to be striving for a common good of all Europe – a compromise with the greatest common denominator, which can be accepted or at least tolerated in all member states. This means for example that even though the EU Commission and the current government of Finland both see radio spectrum primarily as an economic resource and expect significant growth from the mobile industry, the Commission did not simply propose a rapid reallocation of the entire UHF band in the EU as there were too many large member states with their own interests against this idea. Sometimes the European approach can look rather cumbersome and complex – and it can

blamed to be stagnant and not dynamic (Pursiainen 2015). However, the hidden beauty of the “one-size fits all Europe”-approach is that in this way the European Union – the Commission, Parliament and the Council together - usually create a balancing act against extreme or strongly deviating national policies by prioritizing the interest of Europe as a whole over national interests. So the future of broadcasting in Europe is eventually in the hands of the largest and the most influential EU member states: as long as they appreciate broadcasting as a form of communication, it will stay.

Discussion

Perhaps the best answer to the question in the title of this chapter is that WRC-15 represents both an end of an era as well a new beginning. The long era of undisputed European dominance in the ITU Region 1 spectrum planning and the unhesitating or unfaltering support of the interests of the European (public) broadcasters by the respective European governments is most probably over. This does not mean that Europe would have lost its influence and power in the ITU region 1 completely – or broadcasters would have totally lost their special position as a socially and culturally privileged form of communication.

But in order to reach their goals, they have to negotiate more and also make more compromises in the future. The new post-broadcast era will be less stable and more unpredictable: nothing should be taken for granted anymore. There will be more competition or even a political battle over the scarce resources like spectrum on both national and international levels. Moreover, it is very likely that the strategic choices made by the African and Asian countries will shape the European policies more than before and the preferences of the consumers especially in the large Asian markets like India will increasingly shape the policy choices and receiver devices available also for the European markets - and no longer the vice versa. It is likely that the European public service broadcasters (PSB) will end up between a rock and a hard place. In case PSBs do not have sufficient freedom and resources to both expand online and to continue broadcasting, they will not be able to fulfil

their public service mission and legal obligations for universality in the evolving digital media environment (Ala-Fossi and Lax 2016; Ala-Fossi 2016b).

In general, it seems that for the European broadcasters the WRC-15 was more like the victory of Pyrrhos than the outcome of the battle of Salamis. Couple of more victorious WRCs like this one and terrestrial broadcasting will be history in Europe. The WRC-15 was most certainly not a beginning of a new era of peace, harmony and mutual understanding but rather a taster of what is to come in the ongoing conflict over the UHF spectrum space and consequently, the future of the free-to-air terrestrial television broadcasting. The mobile industry wants the UHF band, no matter is television dead or alive, but it certainly would be much easier if terrestrial broadcast television would have first passed away as this creative destruction would release spectrum resources in the evolutionary cycle of the survival of the fittest (Ala-Fossi and Lax 2016). When looking at the coming new era of European broadcasting, it is regrettably easy to agree again with Winston Churchill: "I have nothing to offer but blood, toil, tears and sweat."⁴

⁴ See <http://www.winstonchurchill.org/resources/speeches/speeches-of-winston-churchill/92-blood-toil-tears-and-sweat>

References

- Ala-Fossi, M. (2016a). Why Did TV Bits and Radio Bits Not Fit Together? Digitalization and Divergence of Broadcast Media. In A. Lugmayr & C. Dal Zotto (Eds.) *Media Convergence Handbook - Vol. 1. Media Business and Innovation*. (pp. 265-285). Berlin and Heidelberg: Springer. doi:10.1007/978-3-642-54484-2_15
- Ala-Fossi, M (2016b). The PSM paradox with Net Neutrality. In G. Lowe and Y. Nobuto (Eds.) *Public Service Media Across Boundaries* (pp.45-59). Göteborg: Nordicom.
- Ala-Fossi M (forthcoming, 2016c) The Second Century of Wireless. Radio and the spectrum challenge of mobile communication in the digital era. - In Ignacio Gallego and Manuel Fernández Sande (eds.) *ECREA Radio Research 2015: Diversity, Innovation and Policies*. Madrid: Carlos III University of Madrid.
- Ala-Fossi M and Bonet M (forthcoming, 2016) Clearing the Skies: European Spectrum Policy and Future Challenges of DTT in Finland and Spain. *International Journal of Digital Television*, 7:3.
- Ala-Fossi M and Lax S (2016) The short future of public broadcasting: Replacing digital terrestrial television with internet protocol? *International Communication Gazette* 1748048516632171, first published on February 16, 2016 as doi:10.1177/1748048516632171
- EBU (2015a) Broadcasters applaud WRC-15 decision securing future of free-to-air broadcasting. Available at: <https://www3.ebu.ch/news/2015/11/broadcasters-applaud-wrc-15-decision> (accessed on 14 April 2016).
- EBU (2015b) EBU response to the Public consultation on the Lamy Report: The future use of the UHF TV broadcasting band. Available at: https://www3.ebu.ch/files/live/sites/ebu/files/Publications/Policy%20sheets/EBU%20response%20to%20the%20EC%20consultation%20on%20the%20Lamy%20Report_final.pdf (accessed on 14 April 2016).
- EBU (2016) EBU expresses concern at European Commission UHF spectrum proposals. Available at: <https://www3.ebu.ch/news/2016/02/ebu-concerned-for-future-of-dtt> (accessed on 14 April 2016).
- EC (2005) Commission proposes advancing the single market for radio spectrum use. A press release, 29 September 2005. Brussels: European Commission. http://europa.eu/rapid/press-release_IP-05-1199_en.htm (accessed on 14 April 2016).
- EC (2012) Digital Agenda: Commission moves to foster wireless innovation through sharing of radio spectrum. A press release, 3 September 2012. Brussels: European Commission. http://europa.eu/rapid/press-release_IP-12-929_en.htm?locale=en (accessed on 14 April 2016).
- EC (2015) Telecoms: the backbone of the Digital Single Market. Speech by Vice-President Ansip at European Voice event "Creating Europe's digital highways". Brussels, 24 March 2015. http://europa.eu/rapid/press-release_SPEECH-15-4659_en.htm (accessed on 14 April 2016).

EC (2016a) Proposal for a decision of the European Parliament and of the Council on the use of the 470-790 MHz frequency band in the Union. COM(2016) 43 final. 2016/0027 (COD) 2.2.2016.

Brussels: European Commission. <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52016PC0043&from=EN> (accessed on 14 April 2016).

EC (2016b) Commission proposes to boost mobile internet services with high-quality radio frequencies European Commission, Press release, Brussels, 2 February 2016.

http://europa.eu/rapid/press-release_IP-16-207_en.htm (accessed on 14 April 2016).

EC (2016c) State aid: Commission approves French support for households affected by spectrum reallocation. European Commission. Press release Brussels, 5 April 2016.

http://europa.eu/rapid/press-release_IP-16-1243_en.htm (accessed on 14 April 2016).

EP (2016) Draft Opinion of the Committee on Culture and Education for the Committee on Industry, Research and Energy on the proposal for a decision of the European Parliament and of the Council on the use of the 470-790 MHz frequency band in the Union. COM(2016)0043 – C8-0020/2016 – 2016/0027(COD). European Parliament, Committee on Culture and Education, 6 April, 2016.

<http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-%2f%2fEP%2f%2fNONSGML%2bCOMPARL%2bPE-578.762%2b01%2bDOC%2bPDF%2bV0%2f%2fEN> (accessed on 14 April 2016).

Galperin H (2004) *New Television, Old Politics. The Transition to Digital TV in the United States and Britain*. Cambridge: Cambridge University Press.

GSMA (2015) GSMA Welcomes Multi-Country Support for Sub-700MHz Spectrum for Mobile Broadband at WRC-15. Press release, 29 October 2015. <http://www.gsma.com/newsroom/press-release/gsma-welcomes-multi-country-support-for-sub-700mhz-spectrum-for-mobile-broadband-at-wrc-15/> (accessed 14 April 2016).

Harvey S and Ala-Fossi M (2016) Eroding the assets of citizenship? From broadcast to broadband. International Communication Gazette 1748048516632160 First published on February 21, 2016 as doi: 10.1177/1748048516632160

Juncker, J-C (2014) My Priorities. <http://juncker.epp.eu/my-priorities> (accessed on 14 April 2016).

Kamecke U and Körber T (2008) Technological Neutrality in the EC Regulatory Framework for Electronic Communications: A Good Principle Widely Misunderstood. European Competition Law Review, 29(5): 330–337.

LST(2016) Economic and Social Impact of Repurposing the 700 MHz band for Wireless Broadband Services in the European Union. Final report. A study prepared for the European Commission DG Communications Networks, Content & Technology by LS Telcom and Valdani Vicari & Associati. http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=14175 (accessed on 14 April 2016).

MINTC (2016) Ehdotus Euroopan parlamentin ja neuvoston päätökseksi 470-790 MHz:n taajuusalueen käytöstä unionissa. [Proposal for a decision of the European Parliament and of the

Council on the use of the 470-790 MHz frequency band in the Union] 8 March 2016. Helsinki: Ministry of Transport and Communication.

<https://www.eduskunta.fi/FI/vaski/Liiteasiakirja/Documents/EDK-2016-AK-46486.pdf> (accessed on 14 April 2016).

Pursiainen H (2015) Stagnant spectrum policy. Opinion piece originally published in Kauppalehti, 7 December 2015. <http://www.lvm.fi/en/-/stagnant-spectrum-policy-859099> (accessed on 14 April, 2016).

Sims M, Youell T and Womersley R (2015) *Understanding Spectrum Liberalisation*. Boca Raton: CRC Press.